Streamline Basal Application of Herbicide for Small-Stem Hardwood Control[1]

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ABSTRACT. The effectiveness of low-volume basal application of herbicide—"streamline" application—was evaluated on 25 hardwood species and loblolly pine. Test mixtures were step-wise rates of Garlon 4 mixed in diesel fuel with a penetrant added. Most comparisons tested 10%, 20%, and 30% mixtures of Garlon 4, while tests with saplings and small trees used 20%, 30%, and 40%. Target stems ranged from 2 ft tall to 6 in. dbh. Applications were made in February, using pressure-regulated handguns equipped with straight stream nozzles attached to backpack sprayers. Two bands of the herbicide mixture were applied to two sides of all stems.

After 18 months, susceptible hardwood species with greater than 80% average control at all three **Garlon** *rates were water oak* **(Quercus nigra),** *am. hornbeam* **(Carpinus caroliniana),** *black locust* **(Robinia pseudoacacia),** *boxelder* **(Acer negundo),** *huckleberry* **(Vaccinium elliottii),** *sumacs* **(Rhus** *spp.), southern bayberry* **(Myrica cerifera),** *and mountain-laurel* **(Kalmia latifolia).** *Tolerant species with less than 40% control were souwood* **(Oxydendrum arboreum),** *titi* **(Cliftonia monophylia),** *and yellow poplar* **(Liriodendron tulipifera)** *(>1 in. groundline diameter). Treatment of loblolly pines resulted in an average of* **22%** **mortality.** *Smaller stems were more readily killed than larger stems for all species.*

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Ways are needed to manage the composition and density of hardwood and pine regeneration through selective removals. Wise applications of herbicides offer one of the surest means of eliminating unwanted vegetation. Tree injection is often effective in controlling hardwoods and pines that are greater than 2 in. dbh (Campbell 1985, McLemore 1985, Kossuth et al. 1980). Other methods are being developed for controlling seedling and sapling regrowth using directed foliar sprays, soil spots, and basal bark sprays (Miller, 1988a and b, Thomas et. al 1988, Rachal et. al 1988, Zedaker and Freyman 1988, Brewer et. al 1987). This study investigated the effectiveness of low-volume basal applications, streamline applications, on 25 hardwood species and on loblolly pine of small size. This treatment has been referred to in the past, and still by some, as "thinline," which is not consistent with the terms defined on the herbicide label.

S'treamline treatments have been increasingly used since their initial introduction in 1985. This streamline method was devised by Max Williamson, Southern Region Herbicide Specialist, USDA Forest Service, and William Kline, Research and Technical Assistance Forester, Dow Chemical Corporation. The treatment has commonly used a mixture of Garlon 4 at 20%, Cide-Kick by JLB International Chemicals (a penetrant) at 10%, and diesel fuel at 70%. A handgun attached to a backpack sprayer is fitted with a straight stream nozzle with an output of 0.1-0.2 gallons per minute. The method of application is still undergoing modification, but a common approach is to apply a 2- to 4-in.-wide band of the mixture to one or two sides of unwanted stems. The application is aimed at the smooth bark of juvenile stems less than 3 in. in groundline diameter (gld). This is in contrast to full basal treatments where a less concentrated herbicide mixture (1–4%) is applied to the lower 18 in. of unwanted stems, completely covering the stem to the point of runoff.

Recently reported comparison trials of streamline vs. full basal sprays have shown the streamline treatment to be the more cost effective (McLemore and Cain 1988, Zedaker 1986). This reaffirms the potential for this new treatment and prompts the need for further research into the many variables of rate, penetrants, application method, timing, and species susceptibility. This current study investigated the susceptibility of many species to varying Garlon concentrations in the mixture and the variable of stem size.

METHODS

Study Locations

Four study locations were used: (1) a mountain valley in northwest Georgia, (2) Piedmont slopes in east central Alabama, (3) Coastal Plain slopes and stream-sides in southwestern Alabama, and (4) bluff and bottomland forests along the Mississippi River near Vicksburg, MS. The study locations in Mississippi were hardwood stands having an overstory

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above the test species, while the other locations were young pine regeneration areas. The test species and their initial sizes are given in Table 1.

Experimental Units and Treatments

Garlon 4 was tested in mixtures from 10% to 50% plus 10% penetrant, Cide-Kick, and the remainder in diesel fuel. On most species, 10%, 20%, and 30% mixtures of Garlon 4 were tested. Because of the larger size of mountain-laurel, 30%, 40%, and 50% were compared. With the larger sized trees in Mississippi, 20%, 30%, and 40% mixture were tested.

At each location, 88 trees per species were selected by size criteria. On pine regeneration sites, test trees were to be taller than 2 ft and less than 3 in. dbh, and test stems had to be at least 5 ft apart. In Mississippi, trees were to be 0.5-6 in. dbh, and had to be at least 15 ft apart. All had to show no visible signs of connecting roots. Treatments were then randomly assigned to each tree, with 22 trees assigned to each of the 3 treatments and as untreated checks. Of the 2,464 stems initially tagged, 2,233 could be relocated for final assessment- 19 to 20 observations per treatment.

All applications were made in February 1986, using pressure-regulated handguns attached to backpack sprayers. Pressure was maintained at 15 psi. A straight-stream nozzle on the handgun delivered 0.1 gal/min (Spraying Systems Co. spray tip TP0001). Three different applicators followed the same procedure. The applicator stood 3-4 ft from the stem, aimed and started spraying to the left of the test stems, came across the stem(s) with a constant motion, and back to the right across all stems-producing one 4-in.-wide band. The band was positioned'on the stem(s) less than 16 in. above the groundline.

For the smaller test trees on the regeneration sites, the applicator made one application in this manner, took two steps forward, and applied a second band at a point about 90" around the stem (rootstock) center. Thus, one 4-in. band was applied on about half of the stem's circumference. This procedure followed a recommended operational method where the applicator applies two streaks when approaching a brush clump and then two more, by slightly turning, after passing the clump. Some shielding in multiple-stem rootstocks can be over-

Table 1. Initial height or dbh, average number of stems per rootstock, and height growth factor of the test species.

Test species	Size: Mean	Min		Max	Ave. no. of stems per rootstock	Height[1] growth factor
Pine regeneration test areas:	Height (ft)					
Loblolly pine (*Pinus taeda*)	5.9	2.3	-	8.0	1	2.17
Blackgum (*Nyssa sylvatica*)	4.3	22.3		7.8	4	1.74
Black cherry (*Prunus serotina*)	10.0	4.1	-	20.0	3	1.51
Black locust (*Robinia pseudoacacia*)	7.1	2.6		16.0	2	1.65
Flowering dogwood (*Cornus florida*)	4.6	2.3	–	6.8	a	1.74
Large gallberry (*Ilex coriacea*)	3.3	2.2	–	5.5	5	1.29
American holly (*Ilex opaca*)	5.3	2.8	-	11.5	5	1.71
Huckleberry (*Vaccinium elliottii*)	5.9	2.1	-	12.2	2	1.15
Mountain laurel (*Kalmia latifolia*)	7.4	2.0	–	24.0	2	1.04
Pignut hickory (*Carya glabra*)	6.0	2.5	–	11.5	3	1.39
Post oak (*Quercus stellata*)	5.7	2.3	-	13.3	2	1.46
Red maple (*Acer rubrum*)	6.2	3.8	–	10.8	10	1.52
Sourwood. (*Oxydendrum arboreum*)	5.8	2.7		10.3	15	1.74
Southern Bayberry (*Myrica cerifera*)	8.1	4.2		12.0	4	1.12
Southern red oak (*Quercus falcata*)	7.9	2.8		15.0	2	1.56
Sumacs (*Rhus* spp.)	6.6	3.7		12.5	2	1.32
Sweetbay (*Magnolia virginiana*)	4.0	2.1		7.6		1.62
Sweetgum (*Liquidambar styraciflua*)	10.2	3.8	–	17.0	4	1.23
Titi (*Cliftonia monophylia*)	7.0	3.8		13.0	4	1.34
Water oak (*Quercus nigra*)	a.4	3.0		14.0	2	1.29
Yaupon (*Ilex vomitoria*)	4.4	2.3	–	8.2	3	1.50
Yellow poplar (*Liriodendron tulipifera*)	6.4	2.6	–	11.8	9	1.99
Hardwood stand test areas:	DBH (in.)					
Beech (*Fagus grandifolia*)	2.4	0.6		6.0	1	
Boxelder (*Acer negundo*)	3.7	1.4	–	6.0	1	--
Flowering dogwood (*Cornus florida*)	3.2	0.6	–	6.0	1	--
Eastern hophornbeam (*Ostrya virginiana*)	2.8	0.9		5.7		--
American hornbeam (*Carpinus caroliniana*)	2.4	1.0		5.3		--
Sweetgum (*Liquidambar styraciflua*)	3.1	0.5	-	6.0	1	--

[1] Height growth factor = $\frac{\text{ave. height of check trees after 18 months}}{\text{ave. initial height}}$

come with this approach and complete encirclement of all stems is more likely. Encirclement is thought to be necessary for effective control. Encirclement of most stems of smooth and slightly fissured barks occurs within about 1½ hr after application as the oily mixture spreads around and downward. When treating the larger stems in Mississippi, the two bands were applied to opposite sides of the stem.

Treatment of blotter-paper cylinders showed that the milliliters of streamline mixture applied to stems from 0.5-2 in. could be estimated by the equation: milliliters of mixture = 2.4 x groundline diameter (gld) in inches. Thus, l-in. stems received 2.4 ml of the mixture, and 2-in. stems received 4.8 ml. Application amounts for larger stems were not determined.

Measurements and Analysis

Before treatment, dbh of test stems was measured in Mississippi and total height at the other locations. Post-treatment measurements were made in August 1987, approximately 18 months after treatment. Some large stem species in Mississippi were reassessed 30 months after treatment. On the pine regeneration sites, heights were remeasured and those stems that were completely topkilled were noted along with the presence or absence of resprouting. Resprout heights were included in the height remeasurements. Remeasurements also included the groundline diameter of the largest stem that was killed and the largest living stem. At the time of reassessment, in the Mississippi hardwood stands, crown reduction was ocularly estimated to the nearest 5% by one individual to minimize bias. Complete stem kill and resprouting were noted.

A height growth factor was calculated for the smaller test stems using the height measurements of the check trees as follows: height after 18 mo/initial height (Table 1). The growth factor was used in calculating the percentage of height growth reduction occurring after treatment in the following manner:

$$\text{Percent height growth reduction} = \frac{(\text{initial height x growth factor}) - \text{final height}}{\text{initial height x growth factor}} \times 100$$

Thus, the height of treated crowns was compared to a projected crown height, using the growth rate of the untreated check crowns for the projections.

Analysis of variance was used to test for differences in percent height growth reduction and percent crown reduction as affected by rate. Percentage data were converted to their arcsine equivalents before analysis. Correlations were calculated for control parameters and rate and initial height or dbh. When judging the effectiveness of control, species were considered susceptible with 80% stem-kill or height and crown reduction, and species were considered tolerant of the treatment when 40% or less control occurred.

RESULTS

With these February applications, the susceptible species were water oak, American hornbeam, black locust, boxelder, huckleberry, sumac (a mixture of *Rhw copallina* and *R. glabra),* southern bayberry, and mountain laurel (Tables 2 and 3). Resistant or tolerant species were identified as sourwood, titi, and to some extent, yellow-poplar, but the very small trees of even the tolerant species could be controlled (Table 4).

Loblolly pines were killed 22% (range = 19-25%) of the time. Surviving trees showed about one-third reduction in height growth at each test rate. Even though loblolly pine appears to have considerable tolerance, direct treatment of loblolly stems should be avoided, and care should be exercised by the applicator when treating sites for pine release.

For several species common to many regeneration sites, control did not increase with increasing application rate. Irrespective of rate, height reduction ranged from 60% to 80% for southern red oak (*Quercus falcata*), post oak (*Q. stellata*), hophornbeam (*Ostrya virginiana*), yaupon (*Ilex vomitoria*) and the larger flowering dogwoods; and from 54% to 72% for red maple (*Acer rubrum*). Resprouting commonly occurred on post oak and southern red oak in the second growing season, while little resprouting was observed with red maple.

Species for which increasing the application rate resulted in greater kill were sweetgum, blackgum (*Nyssa sylvatia*), black cherry (*Prunus serotina*), gallberry (*Ilex coriacea),* American holly (*Ilex opaca),* and Sweetgum, blackgum, black cherry, holly, and pignut hickory (*Carya glabra),* and gallberry were most effectively controlled with the highest rate.

For most species, stem size influenced the degree of control more than herbicide rate. There was a significant relationship (0.05 level) between stem size and the degree of control for 13 species, while the rate of application appeared to be significant for only 5 species (Table 2). The average largest diameters that were completely killed are shown in Table 4, along with the "maximum alive stem" as an indication of the maximum diameter tested.

The symptoms of herbicide activity after streamline treatments are often slow to appear. During the first growing season after treatment, defoliation is often gradual, and stem dieback may be progressive. The application band on the stem of many susceptible species acts like a wound allowing entry to insects and disease. On the larger hardwood trees in Mississippi, the deterioration initiated at the wound appeared to be the principle control mechanism. This deterioration was still progressing in the second and third years after treatment, as evident by exudation, discoloration, and upward splitting. From the second to the third year, the number of stems killed by the three trial rates increased by 4%-8% for beech,

Table 2. Pine regeneration area tests: by rate of Garlon, the percent of stems that were completely topkilled (and the percent of those that resprouted) and the percent height growth reduction with the results of the analysis of variance that tested for differences in the rate of Garlon 4.

Species	Garlon:	Percent topkilled (percent resprouted)			Height growth reduction			ANOV[1] by rate
		10%	20%	30%	10%	20%	30%	
Potential main-canopy species								
Loblolly pine		25 (0)	24 (0)	19 (0)	39	33	27	ns
Sweetgum		5 (0)	48 (19)	81 (5)	22	60	91	**
Red maple		36 (0)	54 (9)	43 (10)	54	72	67	ns
Blackgum		5 (0)	28 (15)	42 (15)	19	52	65	**
Yellow-poplar		19 (5)	19 (19)	31 (10)	30	34	56	ns
Oaks:								
water		79 (10)	88 (12)	84 (10)	89	97	93	ns
post		33 (48)	40 (35)	62 (19)	71	73	82	ns
southern red		52 (19)	35 (40)	47 (31)	77	74	77	ns
Pignut hickory		42 (0)	31 (0)	65 (0)	53	52	79	ns
Black cherry		25 (25)	43 (28)	65 (15)	51	69	80	*
Potential midstory species								
S. bayberry		100 (0)	90 (0)	95 (0)	100	92	95	ns
Black locust		81 (5)	95 (0)	86 (0)	89	100	92	ns
Holly		67 (0)	48 (0)	90 (0)	79	66	95	**
Dogwood		28 (0)	43 (0)	50 (11)	50	59	68	ns
Sweetbay		40 (0)	28 (0)	43 (0)	47	38	53	ns
Sourwood		5 (0)	10 (0)	10 (10)	8	34	28	ns
Titi		14 (0)	14 (0)	5 (0)	28	30	26	ns
Mountain laurel[2]		86 (0)	69 (0)	85 (0)	95	82	95	ns
Shrub species								
Huckleberry		95 (0)	95 (0)	100 (0)	96	96	100	ns
Gallberry		38 (0)	76 (0)	95 (0)	56	90	100	**
Sumacs		90 (0)	73 (19)	81 (9)	100	89	92	ns
Yaupon		72 (0)	73 (0)	60 (0)	82	86	73	ns

[1] Results of the analyses of variance testing for differences in height growth reduction as affected by Garlon rate (check data excluded):
* –<0.05 probability.
**–<0.01 probability.
ns = not significantly different.
[2] Test rates were Garlon 4 at 30%, 40%, and 50%.

10%–35% for dogwood, 5%–10% for hophornbeam, and 10%–35% for sweetgum. Thus, stem mortality for these species was approaching 80% by the third year.

RECOMMENDATIONS

Streamline treatments have use as site preparation, release, and TSI treatments for pine and hardwood management. Because the 20% Garlon 4 mixture costs about $14/gal, careful and selective applications must be used. One gallon will treat about 1580 stems that are l-in. gld (on two sides). This makes application to all unwanted stems on many tracts cost prohibitive. The best approach for release may be the selective application to competitors immediately around crop pines and hardwoods.

Table 3. Hardwood stand tests: by Garlon rate, the percent of stems that were completely topkilled (and the percent of those that resprouted) and the percent crown reduction.

Species	Garlon:	Percent topkilled (percent resprouted)			Crown reduction'		
		20%	30%	40%	20%	30%	40%
Sweetgum		35 (0)	35 (5)	65 (5)	39	47	71
Beech		52 (0)	71 (0)	66 (0)	63	88	75
Boxelder		90 (0)	85 (0)	95 (0)	97	98	100
Dogwood		70 (0)	40 (0)	53 (0)	79	66	69
Hophornbeam		65 (0)	55 (0)	60 (0)	81	60	73
Hornbeam		100 (0)	100 (0)	95 (0)	100	100	99

' Results of an analyses of variance found no differences by Garlon rate.

Late-winter streamline treatments are only effective on certain sized individuals of specific species. The maximum stem diameters that can be effectively killed using the medium rate of Garlon 4 are as follows:

<0.5 in. *gld:* blackgum, dogwood, gallberry (<0.3 in.), sweetbay (<0.4 in.), titi

0.6 to *1.0* in. *gld:* loblolly pine, black locust, holly, huckleberry, pignut hickory, post oak, red maple, sourwood, sumac, water oak, yellow poplar

1.1 to I *.5 in. gld:* black cherry, sweetgum, bayberry

I.6 *to* 2 *in. gld:* red oak, mountain-laurel

When treating opposite sides of larger diameter stems:

<2.5 in. dbh: beech, hornbeam, hophornbeam

Table 4. Average groundline diameter and dbh of the largest stems killed by rate and the maximum living stem diameter.

Species	Largest diameter killed			Max. living stem
	....................(in.)........			
Pine regeneration test sites:	Groundline diameter			
Garlon rate:	10%	20%	30%	
Loblolly pine	1.0	1.0	1.1	3.0
Blackgum	.5	.5	.5	6.0
Black cherry	1.2	1.3	1.1	6.4
Black locust	1.0	1.0	.9	2.5
Dogwood	.5	.5	.5	2.0
Gallberry	.3	.3	.3	.8
Holly	.8	.7	.9	2.6
Huckleberry	.8	.6	.6	2.0
Mountain laurel[1]	2.2	2.1	2.5	6.0
Pignut hickory	.8	.9	1.0	2.1
Post oak	1.1	1.0	1.1	2.8
Red maple	.6	.7	.7	2.0
Sourwood	.5	.7	.6	2.4
Southern bayberry	1.6	1.3	1.3	2.7
Southern red oak	1.5	1.6	1.6	3.6
Sumacs	.9	.9	1.0	2.2
Sweetbay	.4	.4	.4	1.1
Sweetgum	.6	1.1	1.2	3.0
Titi	.5	.6	.5	2.2
Water oak	1.0	1.1	1.3	3.0
Yaupon	.5	.4	.6	2.8
Yellow poplar	.8	.7	.8	3.4
Hardwood stand test sites:	Diameter breast high			
Garlon rate:	20%	30%	40%	
Beech	1.7	1.7	2.5	6.0
Boxelder	3.1	3.5	3.8	5.9
Dogwood	2.6	2.6	2.2	6.0
Hophornbeam	2.3	2.5	3.8	5.7
Hornbeam	2.6	2.3	2.7	5.3
Sweetgum	2.7	3.0	3.0	5.9

[1] Test rates were Garlon 4 at 30%, 40%, and 50%.

2.6 to 3.0 in. dbh: dogwood, sweetgum

<3.5 in. dbh: boxelder

Stem sizes below those listed in the headings should be consistently controlled at the 20% rate of Garlon 4. In general, successful treatments should be possible on areas where most stems are less than 1 in. gld, and the target species are comprised mainly of water oak, hornbeam, black locust, boxelder, huckleberry, bayberry, or mountain laurel. Opposite sides of the stems should be treated when sizes exceed 1 in. gld. Larger stems may take at least 3 years for effective control. When treating black cherry, gallberry, holly, pignut hickory, and sweetgum, the higher rate of 30% Garlon.4 should be considered for achieving maximum control. Grown reduction is easier to achieve using the lower rates than complete kill of stems. □

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